

# MULCH BIOWALL FOR ENHANCED BIOREMEDIATION OF CHLORINATED SOLVENTS

## AFCEE/ERT Demonstration at Altus AFB, OK

**Jason C. Gorden**

Air Force Center for Environmental Excellence  
3300 Sidney Brooks

Brooks City-Base, TX 78235-5112

Phone: (210) 536-2199, Email: [jason.gorden@brooks.af.mil](mailto:jason.gorden@brooks.af.mil)

Coauthors:

Bruce M. Henry, Parsons, Denver, Colorado

Patrick E. Haas, Mitretek Systems, San Antonio, Texas

James R. Gonzales, Air Force Center for Environmental Excellence, Brooks City-Base Texas

### Background

A permeable mulch biowall was installed at Altus Air Force Base (AFB), Oklahoma in June 2002 to stimulate reductive dechlorination of chlorinated solvents in groundwater at Landfill 3 (SWMU 7). The remedial objective of the biowall is to attenuate and contain a shallow groundwater plume contaminated with trichloroethene and cis-1,2-dichloroethene, in order to prevent potential off-base migration. The biowall is composed of shredded bark mulch, cotton gin compost, and sand (to increase permeability). This is the second Air Force mulch biowall application to develop this technology. Bark mulch and compost are byproducts of the landscaping and agricultural industries, and can often be obtained for little cost or for the cost of handling alone. These substrates are intended to be used as solid-phase, long-term carbon sources to stimulate reductive dechlorination of chlorinated compounds over periods of 5 years or more.



The Altus AFB biowall was installed in 5 days from June 19 to 23, 2002, using a continuous trencher, measuring 455 feet long by 24 feet deep by 1.5 feet wide. Depth to water varies from 6 to 8 feet below grade, and the trench is intended to intercept over 80 percent of the groundwater plume contaminant flux. A monitoring well network of ten wells was installed, including two wells within the biowall from July 16 to 19, 2002. Groundwater samples were collected and analyzed for chlorinated solvents and their degradation products, dissolved oxygen (DO), nitrate, ferrous iron, manganese, sulfate, hydrogen sulfide, carbon dioxide, methane, ethane, ethane, oxidation-reduction potential (ORP), alkalinity, pH, temperature, specific conductance, total organic carbon (TOC), volatile fatty acids (VFAs), and chloride. Initial baseline sampling at 4 weeks following installation of the biowall indicated that sulfate reduction and methanogenesis had been stimulated within the biowall. The results of process monitoring will determine the effectiveness of the biowall to reduce concentrations of chlorinated ethenes. Evaluation will include analysis of changes in contaminant concentration and molar fraction, depletion of competing electron acceptors, production of metabolic byproducts, levels of dissolved organic carbon and volatile fatty acids, changes in hydraulic conductivity, and the downgradient extent of biowall influence. While true "baseline" conditions for the wells located in the trench (PES-MP01 and PES-MP06) were not obtained, data from upgradient and downgradient wells can be used to infer "baseline" conditions across the site.

The primary contaminants detected at the site include trichloroethene (TCE) and cis-1,2-dichloroethene (DCE), trans-1,2-DCE, and 1,1-DCE. Concentrations of TCE ranged from 48 micrograms per liter (ug/L) at biowall location PES-MP01 to 6,200 ug/L at upgradient location OU-1-01. Concentrations of cis-1,2-DCE ranged from 22 ug/L at location PES-MP03 to 850 ug/L at upgradient location OU-1-01. Low estimated concentrations (less than 1 ug/L) of tetrachloroethene (PCE), vinyl chloride (VC), chloroethanes, chloromethanes, and fuel compounds also were detected. With the notable exception of biowall location PES-MP01, the ratio of TCE to cis-1,2-DCE ranged

from 25:1 to 1.5:1. However, for PES-MP01, the ratio of TCE to cis-1,2-DCE was less than 0.1:1. This suggests that degradation of TCE to cis-1,2-DCE may be enhanced at this biowall location. However, additional monitoring is required to verify this observation.

## Results

Biodegradation causes measurable changes in groundwater geochemistry that can be used to evaluate the effectiveness of substrate addition in stimulating biodegradation. For reductive dechlorination to be an efficient process, the groundwater typically must be sulfate-reducing or methanogenic. Thus, groundwater in which reductive dechlorination is occurring should have the following geochemical signature:

- Depleted concentrations of DO, nitrate, and sulfate;
- Elevated concentrations of ferrous iron, manganese, methane, ethene, ethane, hydrogen, carbon dioxide, chloride, and alkalinity; and
- Reduced ORP.

Comparison of biowall locations PES-MP01 and PES-MP06 to locations outside the biowall can be summarized as follows:

- With the exception of the furthest downgradient well locations, dissolved oxygen levels are already depleted (less than 2 milligrams per liter [mg/L]) in the study area.
- Oxidation-reduction potential in the biowall has been lowered to –266 millivolts (mV) to –365 mV.
- Sulfate levels in the biowall have been depleted to 450 mg/L, compared to background levels of 1,400 mg/L to 2,200 mg/L. Meanwhile, hydrogen sulfide levels are elevated in the biowall at concentrations of 15 mg/L to 32 mg/L.
- Methane levels in the biowall are elevated at concentrations of 7.9 to 8.8 mg/L.
- Carbon dioxide and alkalinity also are elevated within the biowall.
- Total organic carbon in the biowall was measured at 2,800 mg/L at location PES-MP01, and total VFAs (Table 3) within the biowall were measured at concentrations of 959 mg/L to 1,367 mg/L.

## Discussion

Geochemical data indicate that loading of dissolved organic carbon within the biowall has been sufficient to induce sulfate reduction and methanogenesis, oxidation-reduction conditions that are highly conducive to reductive dechlorination of chlorinated compounds. VFAs (metabolic acids) are comprised primarily of short-chain acetic, propionic, and butyric acids. Fermentation of VFAs, particularly propionic and butyric acids, is known to produce molecular hydrogen and to stimulate reductive dechlorination. Insufficient concentration data are available to determine whether reductive dechlorination of chlorinated ethenes is being stimulated at this early date. Concentration data for TCE and cis-1,2-DCE at biowall location PES-MP01 hint that some degradation of TCE may already be occurring. However, additional monitoring is required to verify this observation.

